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Cover story: Quark/gluon taggers light the way to new physics

Quarks and gluons are elementary particles, according to Quantum-chromo Dynamics (QCD), to bound together to form the protons, neutrons and other hadrons. Due to the nature of the strong force in QCD, quarks and gluons are not free particles, rather manifesting themselves in high energy collisions by a bunch of energetic hadrons, dubbed as “jets”. Thus, discriminating a quark from a gluon possesses a significant challenge because of the limited information and poor understanding of the hadronic jets. Yet, it is of fundamental importance to distinguish a quark from a gluon, not only because of the need to understand the QCD to a deeper level, but also the fact that quarks and gluons may lead to different characteristics coming from electroweak interactions and new physics beyond the Standard Model (SM) of the elementary particle physics. This has been known as one of the most important, but challenging tasks at hadron colliders, such as the Large Hadron Collider (LHC).

In a recent article [1] published by ATLAS collaboration at the LHC experiment, a very detailed study on the quark/gluon tagging technique has been carried out and concluded with very promising separation powers. Two quark/gluon tagger methods, charged-particle jet-constituent multiplicity tagger and BDT tagger combining several jet substructure observables, are carefully studied and thoroughly compared for a broad transverse momentum ranging from 500 GeV and 2 TeV and for multiple tagger working points. With a fixed quark-jet efficiency at 50%, both two quark/gluon taggers are demonstrated to reject more than 90% of the gluon jets. Even more importantly, it also makes solid calibration of taggers so that they could be actually used in LHC-ATLAS data analysis. The current publication is an important step forward toward a better understanding of quarks and gluons in QCD and the jets orginated from the electroweak gauge bosons, as well as seeking for signals from new physics beyond the SM.

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References

[1] ATLAS Collaboration, Chin. Phys. C **48**, 023001 (2024), arXiv:2308.00716[hep-ex]